Overview of Science & Technology Requirements

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Earth Science Technology Office

April 13, 2004

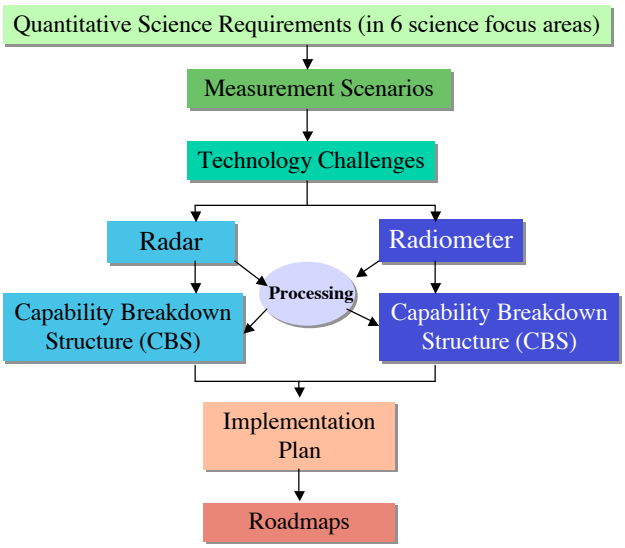
NASA Earth Science Radar/Radiometry Technology Working Group

- Charged to develop detailed technology requirements linked to science requirements in order to guide ESTO's investment strategy
- Community forum was held to gather the larger community input
- Working Group members from NASA centers, academia, and industry
- Azita Valinia (ESTO) Lead
- Waleed Abdalati (GSFC/HQ) Science Lead
- Craig Dobson (HQ) Technology Lead

Members

- Aerospace Corp.: Robert Bitten, Dan Evans, David Glackin, Robert Kellogg, David Kunkee
- Ball Aerospace: Gary Salisbury
- ESTO: Ken Anderson, Azita Valinia
- GSFC: Al Chang, Ed Kim, Rafael Rincon
- JPL: Wendy Edelstein, Yunjin Kim, Ronald Kwok, Soren Madsen, Paul Rosen
- NASA/HQ: Waleed Abdalati, Craig Dobson, Woody Turner
- U. Kansas: Prasad Gogineni
- U, Mass.: Cal Swift
- U. Miami: Tim Dixon
- U. Michigan: Tony England, Mahta Moghaddam, Chris Ruf, Kamal Sarabandi
- UCLA: Yahya Rahmat-Samii

Requirement Definition Process



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Measurements with Microwave Technique

Weather

Atmospheric Temperature and Water Vapor

Cloud Particle Properties*

Cloud System Structure*

Global Precipitation

Storm Cell Properties

Earth Surface & Interior

Land Surface Topography*

Surface Deformation

Terrestrial Reference Frame (VLBI)

Climate Variability

Ocean Surface Currents

Ocean Surface Winds

Ocean Surface Topography

Sea Surface Salinity

Sea Ice Thickness & Extent

Ice Surface Topography*

Atmospheric Composition

Atmospheric Temperature and Water Vapor

Cloud Particle Properties*

Cloud System Structure*

Water & Energy Cycle

Snow Cover

Snow Water Equivalent

Freeze-Thaw Transition

Global Precipitation

River Stage Height/Discharge

Soil Moisture

Carbon Cycle & Ecosystems

Biomass *

Vegetation Canopy*

*Microwave Complementary

Defined Measurement Threshold and Goal Requirements

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Measurement Scenarios

Active Techniques

Synthetic Aperture Radar (SAR) (8)

Interferometric SAR (13)

Atmospheric Real Aperture Radar (8)

Scatterometers (5)

Altimeters (3)

Radio Occultation and GPS Scenarios (3)

Passive Techniques

Real Aperture Radiometers (5)

Real Aperture Sounders (2)

Synthetic Thinned Array Radiometers (STAR) (11)

VLBI (for Earth rotation) (1)

For each scenario technology challenges were identified, and corresponding capability breakdown structure (CBS) was developed.

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Capability Breakdown Structure

Each CBS contains:

- Technology Category
- Measurement Scenario
- Instrument Type
- Waveband
- Needed Functional Product
- Quantitative Requirement
- Task
- Subtask
- Explanation
- TRL @ Start
- TRL @ End
- Development Period (years)
- Year Needed
- Level of Effort (person-year)
- Hardware/ Contract Cost Estimate
- Error in Estimate
- Estimate Source

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Prioritization Criteria

ESE Science Value

- Measurement importance - rated only within a science focus area by HQ program managers
- Measurement timeliness - as determined by ESE science roadmaps (or other relevant document if 'off roadmap' (I.e., SESWG report)

Candidate Scenario Value

- Scenario uniqueness - unique/supporting capability to meet requirement
- Scenario relevance - does scenario meet or exceed requirements for:
  - threshold (T) or
  - goal (G)

Technology Value

- Criticality - is technology
  - enabling (i.e. needed to enable a new measurement capability) or
  - enhancing (i.e. incremental performance improvement OR cost enabling)?
- Utility - how many measurement parameters are served?

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Vegetation Canopy*#

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High priority measurements noted on the science roadmaps requiring investment in technology

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http://esto.nasa.gov/estips

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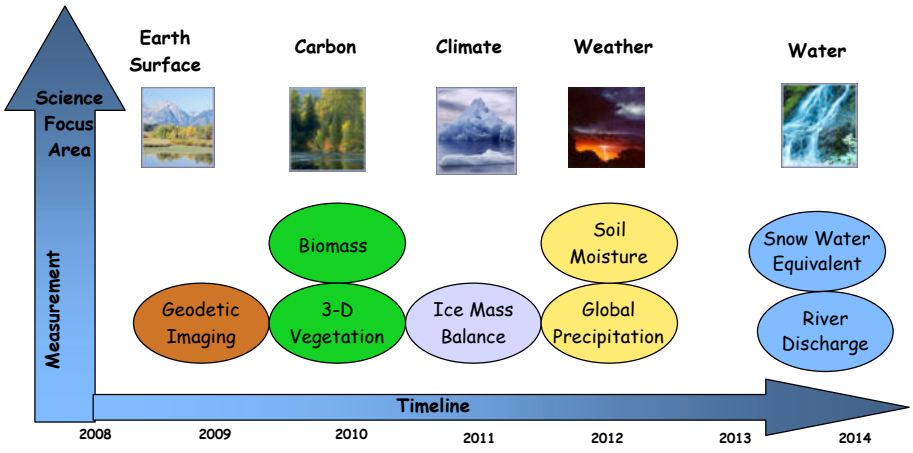
ESE Science Value

Science Importance and Timelines (Extracted from ESE Science Roadmaps*)



* Assuming all measurements across 6 focus areas are equally important.

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Measurement Scenario and Technology Value Combined with Science Value

T Scenario meets all threshold science requirements

E Scenario meets all thresholds and exceeds one or more

G Scenario meets all thresholds and meets one or more goals

Technology Utility

InSAR	E	E	E		E	E	E
SAR	E	T	E/T		E/G	E/T	
STAR				G	G	G	
Real Aperture Radiometer					T	T	
Atmospheric Radar				T			
Scatterometer			T				
Technology/ Measurement	**Geodetic Imaging**	**Biomass**	**Ice**	**Precipitation**	**Soil Moisture**	**Snow Water Equivalent**	**River Discharge**

Timeline

2008 2009 2010 2011 2012 2013 2014

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Roadmaps

Type 1: Integrated technology roadmap corresponding to specific focused science roadmap

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Example: Solid Earth Science Roadmap

Overall Goals:
- Determine the nature of deformation at plate boundaries and the implications for earthquake hazards
- Determine how tectonics and climate interact to shape the Earth's surface and create natural hazards
- Quantify the interactions among ice masses, oceans, and the solid Earth and their implications for sea level

NASA
Joint
Internat'l
Unfunded
T=Technology Development required

Knowledge Base

Non-microwave technique

T Advanced Gravity Measurements from space

Increased predictive capability for earthquakes and sea level based on redistribution of mass

GPS limb sounding (COSMIC)

Long wavelength gravity field, better atmospheric structure to improve GRACE data analysis yielding improved sea-level change estimates

Earth Scope: InSAR, PBO, USArray, SAFOD

T Extremely accurate space-borne radar geodetic imaging (InSAR)

Global and regional volcanic inflation, flooding, land and coastal erosion, fault strain, fire hazard, tectonic strain, precision topography

Local continuous observation of deformation using geodetic imaging from LIDAR and InSAR for prediction of eruption, landslide, flooding

T Airborne repeat pass InSAR & spaceborne lidar

The EarthScope program seeks crustal structure and high temporal and spatial resolution of geodetic imaging of regional deformation processes for improved predictability of earthquake and volcanic activity

Global gravity, glacial volume ocean and land topography measurements (GRACE, Icesat, JASON)

Monthly measurements of the distribution of water within the earth system, leading to increased understanding of sea level change, drought, flooding, & water resources

Models & Prediction: Improved resolution of stress and strength of the crust, fault interaction models, volcano eruption predictions, geodetic reference frame, and Mass flux modeling.

Moderate resolution global geodetic imaging radar (SRTM)

10 fold improvement in global topography yields major impacts throughout earth science (water resources, floods, ecology, crustal dynamics, etc. and applications to infrastructure, aviation, etc.)

NASA Geodetic Network

global geodetic networks provide real time reference frame for surface deformation, real time precision positioning for observations and applications

Prediction of volcanic activity somewhat reliable at week-to- month-scale, while earthquake prediction more reliable at decade-to-century-scales. High uncertainty in sea-level prediction.

2004 2006 2008 2010 2012 2014

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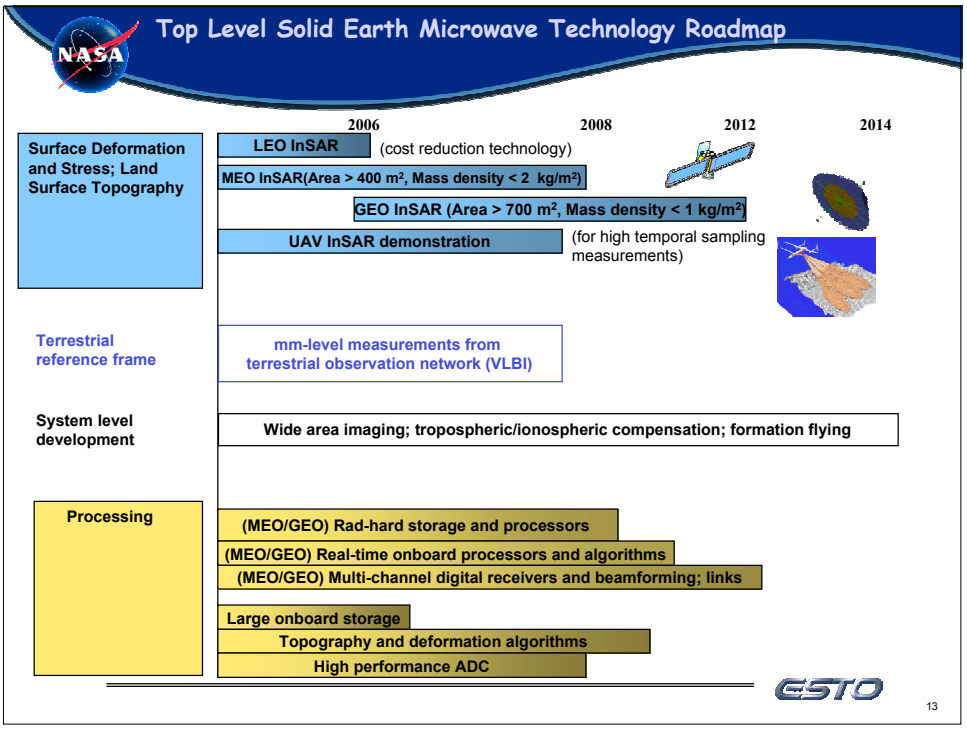
Top Level Solid Earth Microwave Technology Roadmap
2006
2008
2012
2014
Surface Deformation and Stress; Land Surface Topography
LEO InSAR
(cost reduction technology)
MEO InSAR(Area > 400 m², Mass density < 2 kg/m²)
GEO InSAR (Area > 700 m², Mass density < 1 kg/m²)
UAV InSAR demonstration
(for high temporal sampling measurements)
Terrestrial reference frame
mm-level measurements from terrestrial observation network (VLBI)
System level development
Wide area imaging; tropospheric/ionospheric compensation; formation flying
Processing
(MEO/GEO) Rad-hard storage and processors
(MEO/GEO) Real-time onboard processors and algorithms
(MEO/GEO) Multi-channel digital receivers and beamforming; links
Large onboard storage
Topography and deformation algorithms
High performance ADC
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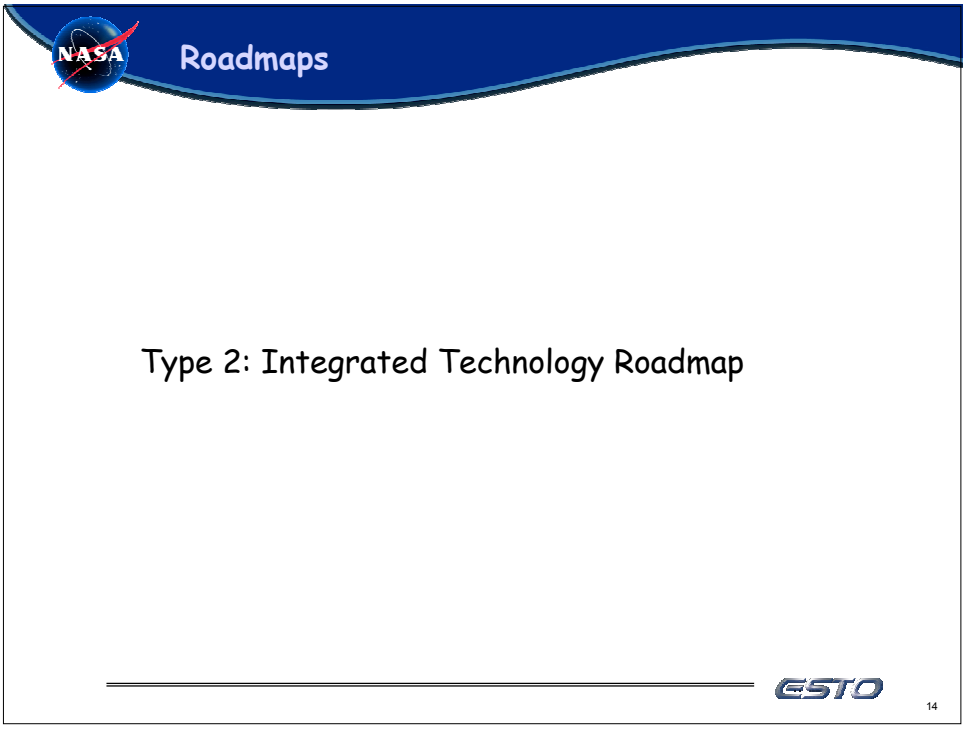
Roadmaps
Type 2: Integrated Technology Roadmap
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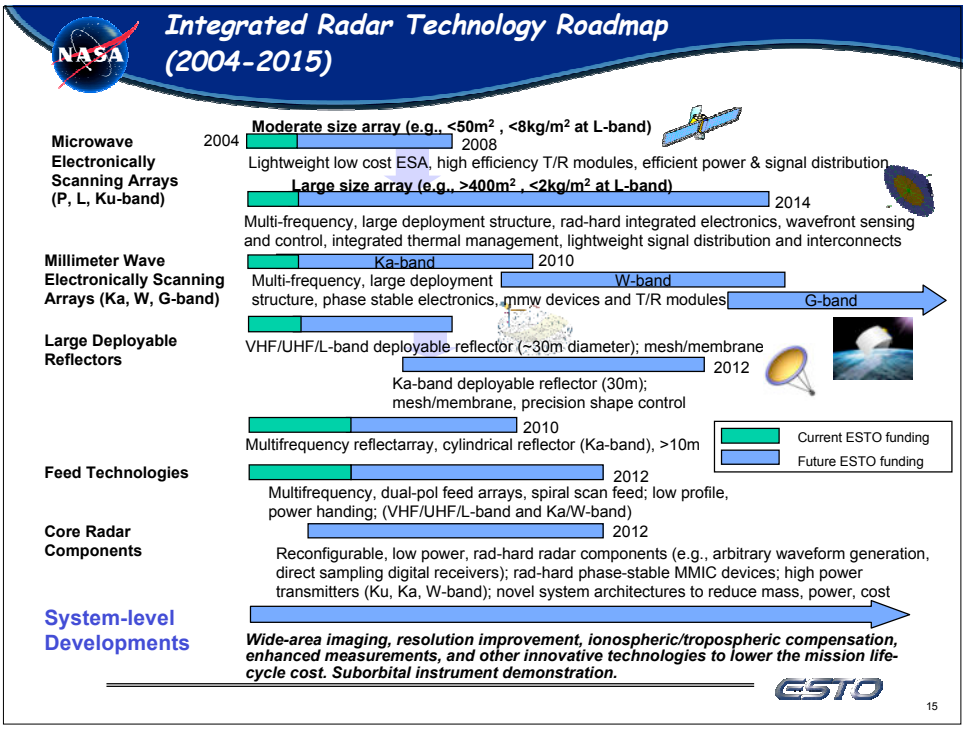
Integrated Radar Technology Roadmap
(2004-2015)
Microwave Electronically Scanning Arrays (P, L, Ku-band)
2004
Moderate size array (e.g., <50m² , <8kg/m² at L-band)
2008
Lightweight low cost ESA, high efficiency T/R modules, efficient power & signal distribution
Large size array (e.g., >400m² , <2kg/m² at L-band)
2014
Multi-frequency, large deployment structure, rad-hard integrated electronics, wavefront sensing and control, integrated thermal management, lightweight signal distribution and interconnects
Millimeter Wave Electronically Scanning Arrays (Ka, W, G-band)
Ka-band
2010
Multi-frequency, large deployment structure, phase stable electronics, mmw devices and T/R modules
W-band
G-band
Large Deployable Reflectors
VHF/UHF/L-band deployable reflector (~30m diameter); mesh/membrane
2012
Ka-band deployable reflector (30m); mesh/membrane, precision shape control
2010
Multifrequency reflectarray, cylindrical reflector (Ka-band), >10m
Current ESTO funding
Future ESTO funding
Feed Technologies
2012
Multifrequency, dual-pol feed arrays, spiral scan feed; low profile, power handing; (VHF/UHF/L-band and Ka/W-band)
Core Radar Components
2012
Reconfigurable, low power, rad-hard radar components (e.g., arbitrary waveform generation, direct sampling digital receivers); rad-hard phase-stable MMIC devices; high power transmitters (Ku, Ka, W-band); novel system architectures to reduce mass, power, cost
System-level Developments
Wide-area imaging, resolution improvement, ionospheric/tropospheric compensation, enhanced measurements, and other innovative technologies to lower the mission life-cycle cost. Suborbital instrument demonstration.
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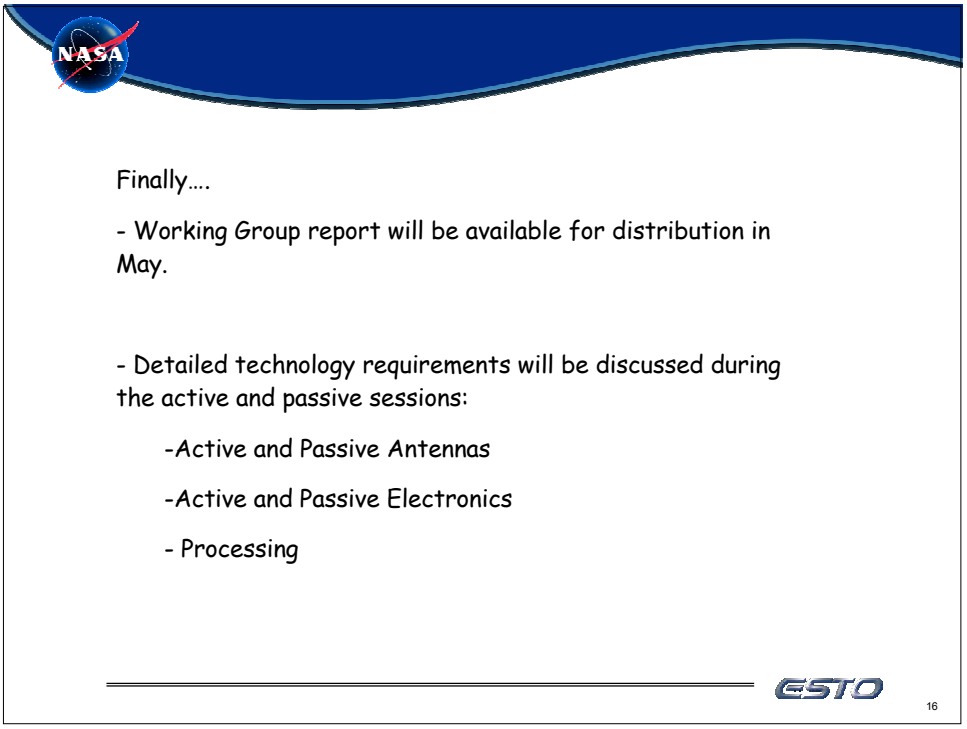
Finally….
- Working Group report will be available for distribution in May.
- Detailed technology requirements will be discussed during the active and passive sessions:
-Active and Passive Antennas
-Active and Passive Electronics
- Processing
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